

REMARKS

Claims 52 and 121 have been cancelled without prejudice or disclaimer. Claims 129 and 138 have been rewritten in independent form. Claim 138 has also been amended to recite that the anode comprises a liquid metal comprising tin. Support for this amendment can be found in the specification, for example, on page 10, lines 6-20. Claims previously dependent on claims 52 or 121 have been rewritten to depend from claims 129 or 138. No new matter has been added.

Claims 116-120 and 123-145 are now pending for examination.

Rejections under 35 U.S.C. §102(b) in view of Koch

Claims 52, 116-121, 123-128, 130-132, 137 and 139-141 have been rejected under 35 U.S.C. §102(b) as being anticipated by Koch, German Patent No. DE 4004220 C1 ("Koch").

Initially, it should be noted that the Applicants' analysis of Koch is based upon as translation cited to the Patent Office in an Information Disclosure Statement filed July 3, 2007.

Applicants have cancelled claims 52 and 121, thus rendering their rejection moot. Claims 129 and 138, now in independent form, each recite a solid-state electrolyte in ionic communication with an anode. It is not seen where Koch discloses or suggests a solid-state electrolyte. Such a modification would render Koch nonfunctional, as a liquid electrolyte containing SnO_2 in equilibrium with liquid Sn is necessary for Koch to oxidize carbon. In Koch, a platinum electrode (5 in Fig. 3) oxidizes tin to form tin oxide, which in turn, oxidizes carbon to form carbon dioxide, thereby regenerating the tin (Sn^0), in the reaction $\text{C} + \text{SnO}_2 \leftrightarrow \text{Sn}_{(l)} + \text{CO}_2$ (Equation 12 in the original German version¹). In Koch, this two-step reaction is used to reduce the changes in the enthalpies of reactions (see page 5, paragraph 1, and page 6, paragraph 2). It is not seen how this reaction could proceed if Koch used a solid-state electrolyte. Thus, Koch does not anticipate claims 129 or 138, and it is respectfully requested that their rejection be withdrawn. The remaining claims each now depend, directly or indirectly, from claims 129 or

¹ The English translation of Koch erroneously shows this reaction as " $\text{C} + \text{SnO}_2 \leftrightarrow \text{Sn}_{(l)} + \text{CO}_2$." Of course, chemistry symbols and equations are generally universal, so the meaning of this reaction is clear in the German patent even without the English translation.

138, and should be allowable for at least the same reasons. Withdraw of the rejection of these claims is also respectfully requested.

Moreover, it is not conceded that Koch teaches the use of tin or any other metal as an anode that is liquid at a temperature at which the anode is operated. In fact, Koch states that “a preferred embodiment of the semi-system according to the invention works with molten tin (Sn) *as a secondary fuel* at a working temperature of 900°C.” [Emphasis added.]

Rejections under 35 U.S.C. §103(a) in view of Koch and Horita

Claims 52, 129, 132, 135, 136, 138, 141, 144, and 145 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Horita, *et al.*, UK Patent Application No. GB 2,278,010 (“Horita” or “Teruhisa”). The Patent Office states that it would be obvious to insert the teachings of Horita into the teachings of Koch because “the electrochemical device would be more efficient by chemically recharging the anode, as described in Teruhisa et al. Additionally, the cathode material described in Koch is platinum, as it is in Teruhisa et al.”

Respectfully, it appears that the Patent Office has used hindsight reasoning in forming this combination of references. For instance, the Patent Office states that Horita suggests that a more fuel efficient electrochemical device is desired, and that this could be achieved by chemically recharging the anode. However, the entire fuel cell art, since the first fuel cell was invented, has always strove for greater fuel efficiency. There are literally hundreds of different ways the efficiency of a fuel cell could be improved, and thus, merely desiring to improve fuel efficiency would not allow a person of ordinary skill in the art to predict that Horita and Koch could be combined, nor would it be obvious to try every potential combination of fuel cell references in the hopes of discovering that Koch and Horita could be combined as suggested by the Patent Office. Furthermore, with respect to the suggestion that a more efficient electrochemical device could be achieved by chemically recharging the anode, it is not seen where this is disclosed in Horita or in Koch. In fact, chemically recharging the anode could result in a *less* efficient electrochemical device fuel cell since some energy would be required to chemically recharge the electrode.

Regarding the fact that both Koch and Horita disclose platinum electrodes, this statement also does not suggest to a person of ordinary skill in the art that Koch and Horita could be combined. There are hundreds of different designs of fuel cells (e.g., metal hydride fuel cells, electrogalvanic fuel cells, microbial fuel cells, proton exchange membrane fuel cells, solid oxide fuel cells, phosphoric acid fuel cells, etc.), nearly all of which can be used in conjunction with platinum electrodes. Platinum is a common metal that is used in fuel cells and related devices due to its electrical conductivity, chemical unreactivity, etc. Accordingly, a statement that Koch and Horita both happen to suggest platinum electrodes, in view of the hundreds of different types of fuel cells that have been disclosed in the art, would not be sufficient to allow a person of ordinary skill in the art to predict that Koch and Horita could be combined in the manner suggested by the Patent Office, nor would it be obvious to try every potential combination of fuel cell references in the hopes of discovering that Koch and Horita could be combined.

Moreover, it is not clear how the combination of Koch and Horita could even be made. Koch describes a particular type of fuel cell which requires an equilibrium reaction to be set up between tin oxide and tin. See, e.g., page 5, paragraph 1, and page 6, paragraph 2. Fig. 3 of Koch shows that in order for the device of Koch to work, the electrolyte and the liquid tin should be free to exchange ions back and forth, i.e., from SnO_2 to Sn^0 and vice versa. The tin, in turn, is in electrical contact with the anode (5 in Fig. 3). In particular, in Koch, carbon cannot be oxidized without also regenerating the tin ($\text{C} + \text{SnO}_2 \leftrightarrow \text{Sn}_{(l)} + \text{CO}_2$), i.e., the electrolyte must be liquid in Koch in order for this reaction to occur.

It is not clear how this reaction could be accomplished by substituting in the teachings of Horita for Koch. Horita describes the use of a vanadium carbide electrode and a yttria-stabilized zirconium as the electrode. In order to substitute in the solid-state electrolyte of Horita, one would need to construct a different type of fuel cell, as either the electrolyte would need to contain a reduced form of vanadium carbide (e.g., vanadium) or an oxidized form of yttria-stabilized zirconium as the electrode in order for the device to work as the Patent Office suggests. In particular, vanadium carbide has a melting point of about 2800 °C, which is significantly greater than the melting point of the electrodes (platinum, 1770 °C) or the chamber itself (constructed out of aluminum oxide, which has a melting point of roughly 2000 °C), thus leading

to the prediction that the device would be non-functional, and yttria-stablized zirconium is already in an oxidized form that cannot be easily oxidized further. Accordingly, it is not seen how the teachings of Horita could be combined with teachings of Koch in order to form a working device. Thus, it is believed that the combination of Koch and Horita is improper, for at least the reasons discussed above, and it is respectfully requested that the rejection of these claims be withdrawn.

Rejections under 35 U.S.C. §103(a) in view of Koch, Badwal, and Breault

Claims 52, 133, 134, 142, and 143 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Koch in view of Badwal, *et al.*, U.S. Patent No. 5,942,349 ("Badwal") and further in view of Breault, *et al.*, U.S. Patent No. 4,824,739 ("Breault"). The Patent Office states that the rationale for making the combination of references "it would be a protective advantage and advantageous to the life of the electrochemical device if it were able to repair itself. In addition, a sealant precursor is advantageous in order to have more flexibility in the placement of the seals throughout the device."

The Patent Office has not pointed to anything in the record to support such a rationale, other than the Applicants' own disclosures, which is hindsight reasoning. Nowhere does Koch disclose or suggest a self-repairing device or a sealant precursor, and one of ordinary skill in the art could not have predicted that a self-repairing device could have been made by modifying Koch, as the ability of a fuel cell to repair itself would depend on many factors, such as the composition of the fuel cell and the conditions under which it is operated. Accordingly, merely desiring a fuel cell to repair itself does not lead one of ordinary skill in the art, even using ordinary creativity, to be able to envision a working device able to repair itself. In fact, the references pointed to by the Patent Office, Badwal and Breault, further show that it is not trivial to envision a device able to perform in such a manner, as the combinations of Badwal and/or Breault with Koch would result in predictably inoperable devices, as discussed below.

For instance, Koch and Badwal could not be combined to form a workable device. As discussed above, there are hundreds of types of fuel cells, and Koch and Badwal use different operating fluids and different principles of operation. The working fluid in Koch is the

conversion of tin oxide to tin. However, the working fluid in Badwal is not tin, but is chromium and chromium oxide (CrO_3), which does not react in the same way that tin does during an electrochemical reaction. Moreover, the self-repair aspect of Badwal occurs between the air electrode/electrolyte interference and the chromium oxide produced by the interconnect device between adjacent fuel cells. In Badwal, an oxide coating is formed on an interconnect surface that comprises chromium Cr_2O_3 , which prevents the evaporation of CrO_3 through this surface coating. This coating “self-repairs” by binding any CrO_3 that enters the coating. See Col. 3, lines 43-49 of Badwal. It is not seen where Koch uses an interconnect device or chromium; if Koch were modified to use an interconnect, it would have to be positioned *between* two copies of the fuel cell as shown in Fig. 3 of Koch. The position of such an interconnect would thus not be in contact with the tin of Koch (2 in Fig. 3). Additionally, Koch does not teach or suggest a layer of tin oxide; in fact, Koch suggests *liquid* tin, which cannot be used to stably coat an interconnect or an electrode. Moreover, the tin oxide in Koch is *required* for the reaction to occur; it cannot simultaneously be used to *prevent* a reaction from occurring as a “self-repair” feature. Accordingly, it is unclear how Koch and Badwal could be combined in a way that would result in a functional self-healing device.

Even if Koch and Badwal could be combined, it is not seen how the combined device could be further combined with Breault, as suggested by the Patent Office. Initially, the Patent Office has not even pointed to anything in Breault beyond suggesting that it teaches a sealant precursor. The abstract of Breault teaches the use of a sealing material in a seal region to form a hydrophilic barrier to gas with an electrolyte, and a hydrophobic layer to block loss of electrolyte from the hydrophilic layer, i.e., Breault teaches the use of a sealing material that is both gas impermeable (to prevent loss of reactant gas) and liquid impermeable (to prevent loss of electrolyte). See, e.g., Col. 7, lines 37-51 (suggesting the use of polytetrafluoroethylene or similar polymers as a hydrophobic liquid barrier to prevent loss of liquid). Thus, Breault teaches the use of a sealing material to prevent loss of a *liquid* electrolyte, in stark contrast to Badwal which teaches the use of a *solid* electrolyte. If a solid electrolyte was used, the use of a hydrophobic liquid barrier to prevent loss of liquid electrolyte would obviously be unnecessary, and thus, these references teach away from each other. Thus, Applicants do not see how Koch,

Badwal, and Breault could be combined in a predictable fashion in order to produce a workable device. Accordingly, it is believed that this combination of references is improper, and it is therefore respectfully requested that the rejection of these claims be withdrawn.

CONCLUSION

In view of the foregoing, this application should now be in condition for allowance. A notice to this effect is respectfully requested. If the Examiner believes, after this response, that the application is not in condition for allowance, the Examiner is requested to call the undersigned at the telephone number listed below.

If this response is not considered timely filed and if a request for an extension of time is otherwise absent, any necessary extension of time is hereby requested. If there is a fee occasioned by this response, including an extension fee, that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 23/2825, under Docket No. T0457.70019US00.

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